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# Mechanism for assessing the competitiveness of an industrial enterprise in the information economy

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### ABSTRACT

The article establishes that the development of an industrial enterprise in the conditions of the information economy requires an assessment of the competitiveness of the enterprise. To solve this problem, a mechanism for assessing the competitiveness of an industrial enterprise in the information economy is developed, which is based on a complex of models for assessing the components of the competitiveness of an industrial enterprise and comparing them with the indicators of the competitive environment. Using the developed mechanism in the activity of an industrial enterprise makes it possible to assess its state in the aspect of adaptability to the information economy and provides the basis for developing solutions for further development of the enterprise.

**Keywords:** mechanism; evaluation; competitiveness; industrial enterprise; information economy; model; development.

### 1. Introduction

The development of an industrial enterprise in any context requires comparisons with other enterprises and the determination of the place of an enterprise in the environment. That is, it is necessary to assess the competitiveness of an industrial enterprise, its ability to meet the conditions of the modern world. Today, the global economy is increasingly gaining ground in the information economy.

Traditionally, in the information economy, there are three main areas: a) manufacture of equipment and electronic equipment for collecting, storing, processing, transmitting and displaying information, b) information activity of enterprises and organizations in the process of production and sale of goods and services, c) provision of services for the collection, storage, processing, transmission and display of information.

In the context of the development of an industrial enterprise, the first two areas deserve special attention. The third area of service provision is not the main thing for industrial en-

terprises, whose feature is the processing of raw materials and materials for the purpose of creating a new product. Although the share of the first sphere is increasing in the conditions of the information economy, but not all industrial enterprises carry out the production of equipment and electronic-technical means for working with information. At the same time, all industrial enterprises are in need of information activities in the production and sale of goods. The information economy is characterized by the emergence of new, innovative mechanisms for the implementation of information activities, which significantly expands the capabilities of the industrial enterprise in the performance of its functions.

Industrial enterprises, which lag behind with the introduction of innovative mechanisms of information activity, cease to meet the requirements of the economic environment, which is modernized in accordance with the development of the information economy, and lose in the competition to more innovative enterprises. Thus, for the development of an industrial enterprise in the conditions of the infor-

mation economy, it is necessary to evaluate its competitiveness in terms of compliance with innovative approaches to the implementation of information activities.

## 2. Literature review

The peculiarity of the information economy is its rapid development, in which every few years there are technologies that bring changes in the economy of almost all countries and change the universe (Aumann & Heifetz, 2002), (Chodera et al., 2013), (Gulati et al., 2013), (Kwilinski, 2017, 2018a, 2018b), Lippman & McCall, 2015), (Lakhno et al., 2018), (Lis & Mazurkiewicz, 2018), (Marston, 2011), (Mycielski, 1992), (Oishi, 2013), (Pajak et al., 2016), (Sun et al., 2017), (Vietor & Weinzierl, 2012), (Yakubovskiy et al., 2016), (Zhang et al., 2012), (Zhang, 2013). The trends of recent years are the development of high-speed wireless Internet, mobile devices with significant computing power, the coverage of most consumers with social networks, the accumulation of significant amounts of information on consumer behavior, the development of methods for processing information using methodologies of Big Data, BlockChain, ect. Due to the variability of the information economy, there are no classical approaches adopted by the whole scientific community to assess the competitiveness of an industrial enterprise in the information economy (Kwilinski, 2017, 2018a, 2018b), (Zhang, 2013). The research of approaches to assessing the competitiveness of an industrial enterprise in the information economy was carried out by many researchers who have solved some of the components of this multifaceted problem.

N. V. Valkova (2015) investigated the role of the information component in the competitive advantages of an enterprise that functions in the conditions of the information economy. At the same time, Kwilinski (2017, 2018a, 2018b) considered the main groups of methods for assessing competitiveness under various classification features and proposed SWOT-analysis of competitive advantages of the enterprise in the conditions of the information economy. As the main evaluation criteria, Valkova proposes to assess the availability of its own site, e-store, participation in electronic auctions and social networks, etc. Among the shortcomings of this approach is the lack of formalized methods for assessing competitiveness in the information economy. In addition, the listed factors to be taken into account in the assessment of competitiveness cover only the marketing aspects of the enterprise, ignoring the need to evaluate internal information flows.

T. Halimon (2016) considers information technology as a platform for managing the competitiveness of the enterprise and proposes the principles of constructing information and organizational design as solutions to the problem of the management of competitiveness. Thanks to using these principles or the dominants, T. Halimon proposes to provide accurate information on the passage of production processes, the coordination of internal activities, the dissemination of messages, as well as the use of system analysis in the operational management of the middle and lower levels of the enterprise. The disadvantage of the approach is to identify domains only in the form of declarative directions, without strict formalization, which would enable to simulate the competitiveness of the enterprise and compare the achieved competitive advantages with the indicators of other enterprises operating in the same industry and region.

A. V. Shmatko and N. G. Fonta (2015) offer to evaluate the competitiveness by calculating the continuous monitoring of the information system of the ratio of total profit to the enterprise costs and comparing the obtained indicator with the standard. The competitiveness indicator is calculated not only on the actual but also on the forecast, which is obtained by extrapolating existing trends. Due to extrapolation, the authors propose to identify problem situations and carry out their automated analysis with the use of computer-based functional diagnostics using hierarchy and SWOT-analysis methods. The main disadvantage of the approach is the choice of an indicator that characterizes competitiveness, since profits and costs are only the consequences of other factors that characterize the existing competitive advantages. An enterprise can have low competitiveness, but it will affect its profit only after some time. In addition, profit and expense may depend on factors other than competitiveness.

O. G. Dzeba and O. P. Romanko (2014) investigated the use of modern information technologies in machine-building enterprises in the aspect of increasing their competitiveness in the conditions of the scientific and technological revolution and the globalization of economic processes. Increasing competitiveness (Dzeba & Romanko, 2014) is offered through the introduction of continuous information support of the product life cycle, comprehensive automation of production and the integration of various information systems into a single enterprise management complex. These measures are promising and effective, but researchers remain out of the question how competitiveness should be assessed in comparison

with other enterprises and how information economy requirements should be taken into account. In addition, the features of domestic industrial enterprises, including machine-building, which have their peculiarities in production and marketing processes that make it impossible to copy western mechanisms, are not taken into account.

A. Reva and A. Smirnov (2010) propose to increase the competitiveness of the enterprise through the introduction of information systems and technologies taking into account the peculiarities of the life cycle. Reva and Smirnov draw the conclusion that information systems are rapidly evolving, and therefore their importance for the scientific, technical and economic development of society is expected to grow. At the same time, the study (Reva & Smirnov, 2010) lacks formalized methods that would link the development of information systems of an enterprise with its competitiveness.

A. V. Zhytkevych and A.O. Azarova (2015) have analyzed the software tools that can be used to calculate the assessments of the level of competitiveness of enterprises. Due to the identified shortcomings and benefits of the software under consideration, the most relevant tools for assessing competitiveness can be identified for each type of enterprise. Zhytkevych and Azarova use information and analytical technologies, decision support systems as well as global telecommunication technologies as tools for evaluating competitiveness (Zhytkevych & Azarova, 2015). However, without denying the promise of the conclusions reached, it should be noted that considering the software products does not provide the opportunity to compare the competitive environment of enterprises and to obtain a quantitative characteristic of the competitiveness of each of the enterprises.

### 3. Methodology

The existing research on the problem of assessing the competitiveness of an industrial enterprise in the conditions of the information economy has solved some of the components of this problem, but still many tasks remain unsolved. Among them, the main ones are: a) formalization of the methods of obtaining an integrated quantitative assessment of competitiveness, b) taking into account the constant emergence of new technologies caused by the development of the information economy, c) taking into account in the assessment of the competitiveness of domestic enterprises the technological gap between the Ukrainian industry and developed countries around the world, d)

construction of a holistic mechanism for assessing the competitiveness of an industrial enterprise in the information economy.

Under the mechanism for assessing the competitiveness of an industrial enterprise in the information economy, we mean a set of interacting elements and integral tools for collecting and processing information, the purpose of which is to obtain estimates of the competitiveness of an industrial enterprise in its operation in the conditions of the information economy. This mechanism should address the above-mentioned tasks and provide the management system of the industrial enterprise with the bases for developing measures for its development in the conditions of the information economy taking into account the existing and potential competitiveness of the enterprise.

### 4. Results and Discussion

It is proposed to build a mechanism for assessing the competitiveness of an industrial enterprise in the information economy based on three models. The first one is a model of comparative evaluation of the competitiveness of an industrial enterprise, which makes it possible to compare the company with competitors or with world leaders. The second one is a model for assessing the capacity of an industrial enterprise to introduce new technologies that are constantly emerging in the information economy. The third component is the integrated quantitative assessment of competitiveness, which allows comparing such complex and multi-element characteristics of the enterprise as the competitiveness of different enterprises. A model for comparative assessment of the competitiveness of an industrial enterprise provides an opportunity to calculate indicators that characterize the competitive advantages or disadvantages of an industrial enterprise in the aspect of functioning in the information economy and compare them with other enterprises, competitors in the industry and the region where the enterprises operate or enterprises that are world leaders this area (Fig. 1).

The comparative evaluation is carried out in two stages. First, indicators are calculated, characterising the adaptability of the industrial enterprise to its functioning in the conditions of the information economy. Such indicators are offered: the degree of automation of production, the degree of informatization of business processes and the degree of representation of the enterprise in the information space.

The indicator of the degree of automation of production characterizes which percentage of production and technological processes is au-

tomated, that is, the implementation of which is carried out without human involvement or with human intervention only for the adoption

of responsible and unstructured solutions (Borodin, 2006; Bryukhanov et al., 2005).

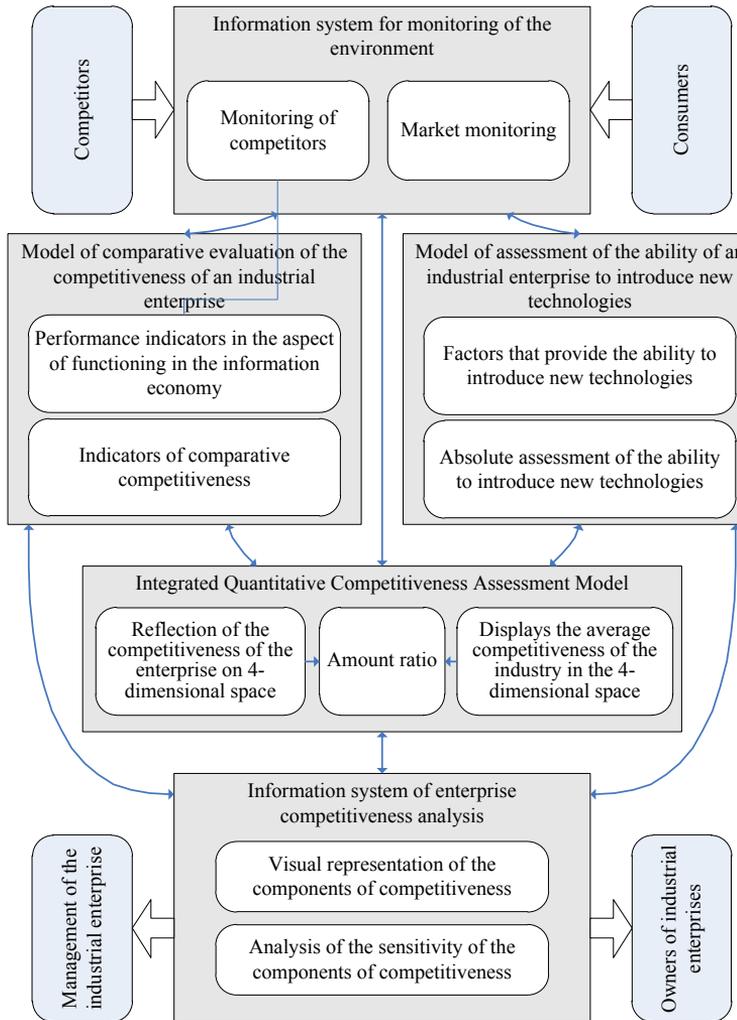


Figure 1. Mechanism for estimating the competitiveness of an industrial enterprise in the information economy  
Source: own study

Calculation of the index of the degree of automation of production is proposed to take into account the contribution of each technological process to the final value of manufactured products and the importance of these products for the enterprise. This will take into account the importance of each of the technological processes in terms of the value added it provides and its impact on the financial result of the enterprise. The formula for calculating the degree of automation of production has the following form (formula 1-2):

$$S^a = \sum_{p=1}^P (w_p \cdot O_p^a), \tag{1}$$

$$w_p = \sum_{g=1}^G \left( \frac{V_g}{V} \cdot \frac{\varpi_{g,p}}{\Omega_g} \right), \tag{2}$$

where:

- $S^a$  – the degree of automation of production;  
 $w_p$  – the weight of the p-th technological process;  
 $O_p^a$  – evaluation of automation of the p-th technological process;  
 $V$  – sales volumes of g-th products;  
 $V^g$  – total volume of sales of the enterprise;  
 $\omega_{g,p}$  – the added value provided by units of g-th products is the p-th technological process;  
 $\Omega$  – unit cost of g-th products;  
 $P^g$  – number of technological processes used by the industrial enterprise;  
 $G$  – number of types of products manufactured by an industrial enterprise.

Estimating the automation of the technological process is carried out in the range from 0 to 1 and has the criteria of formation, shown in Table 1. Full automation refers to a transfer of all functions of control over the execution and management of equipment or technical means. Partial automation is automation of individual operations, machines (Borodin, 2006; Bryukhanov et al., 2005). In addition, the stages of the formulation of the production task and its technological process, the direct execution of the technological process and the correctness of the implementation of the production task are considered separately.

Table 1: Estimating automation of the technological process

Elements of automation of the technological process	Quantitative evaluation of automation			
	Complete	Partial, more than 70% of operations	Partial, from 30% to 70% of operations	Partial automation of some individual operations
Achievement of production tasks	0.20	0.15	0.10	0.05
Performance of production tasks	0.40	0.30	0.20	0.10
Control over performance of production tasks	0.40	0.30	0.20	0.10

Source: calculated by the authors.

The indicator of the degree of informatization of business processes reflects the percentage of business processes of the industrial enterprise formalized and translated into an electronic form. Under business processes, it means a set of related actions whose purpose is to create a product or service, or to ensure that such actions are performed (Repin, 2013). That is, business processes can be operational – which directly creates the product, management – that provides a coordinated operation of the enterprise and business support processes (Repin, 2013).

In the conditions of the information economy not all three types of business processes are important, only the operational ones and only the production business processes that are fundamental to the industrial enterprise but also business processes of other areas of the company's activity – marketing, personnel management, accounting and management accounting, ect. Informatization of business processes means that the business process has a formal description in the form of a job description and there is a reflection of the execution of this business process in the information system of the industrial enterprise.

The calculation of the degree of informatization of business processes of an industrial enterprise is proposed to be carried out according to formula 3.

$$S^i = \frac{\sum_{b=1}^B O_b^i}{B}, \quad (3)$$

where:

- $S^i$  – the degree of informatization of business processes;  
 $O_b^i$  – the sum of evaluations of information of the b-th business process according to all the component criteria;  
 $B$  – the number of business processes in the industrial enterprise.

For each business process, informatization can be complete when the entire business process is formalized and translated into an electronic form, or partially. The criteria for assessing the informatization of business processes are presented in Table 2.

Table 2: Estimation of informatization of business processes

Coverage of business processes by informatization	Quantitative assessment
Availability of a formal description of the business process	0.2
The presence of an accompanying business process of electronic document flow	0.2
Depiction of the state of the business process execution	0.3
Reflection of responsible for the execution of the business process	0.2
The presence of an automated system of alerts on deviations from the schedule of execution of business processes	0.1

Source: calculated by the authors.

An indicator of the degree of an enterprise in the information space reflects how an industrial company uses information communications and how much information is proven to its actual and potential counterparts. In the modern world, it is very important that information about business is easy to find, in addition, the active use of information communications over the Internet allows you to save time and significantly accelerate the interaction. It is very important to have a full range of products on the site and API (application programming interface, application interface) for working with contractors. This enables contractors to quickly find the goods and services they need, and also to execute orders and control their execution. That is, it is an important competitive advantage provided by the information environment.

The calculation of the indicator of the degree of representation of an enterprise in the information space is carried out by drawing up estimates of the availability of each of the possible competitive advantages in the area of information space, taking into account the expert assessment of the quality of implementation of this advantage (formula 4).

$$S^p = \sum_k e_k \cdot O_k^p, \quad (4)$$

where:

- $S^p$  – the degree of informatization of business processes;
- $e_k$  – expert assessment of the quality of the implementation of the p-th competitive advantage in the field of representation of the industrial enterprise in the information space;
- $O_k^p$  – evaluation of the p-th competitive advantage in the field of representation of the industrial enterprise in the information space.

An expert assessment of the quality of the implementation of a competitive advantage in the field of representation of an industrial enterprise in the information space should take into account the quality of implementation in comparison with competitors, when the best implementation is considered to be 100%, while others are compared with it. The importance of each competitive advantage is estimated according to the data presented in Table 3.

Table 3: Assessment of enterprise representation in the information space

Competitive Advantages	Quantitative assessment
The presence of your site on the Internet	0.10
Permanent site update	0.10
Availability of a full range of products on the site	0.20
Availability of API for work with contractors	0.20
Regular participation in exhibitions	0.20
Participation in public tenders through the system Prozorro	0.10
Interaction with state authorities through Internet communication	0.10

Source: calculated by the authors.

$$S_{min}^E = \sqrt{(S^a - S_{min}^a)^2 + (S^i - S_{min}^i)^2 + (S^p - S_{min}^p)^2}, \quad (5)$$

$$S_{max}^E = \sqrt{(S^a - S_{max}^a)^2 + (S^i - S_{max}^i)^2 + (S^p - S_{max}^p)^2}, \quad (6)$$

$$S_{avg}^E = \sqrt{(S^a - S_{avg}^a)^2 + (S^i - S_{avg}^i)^2 + (S^p - S_{avg}^p)^2}, \quad (7)$$

where:

$S_{min}^E$  – the degree of informatization of business processes;

$S^a$  – the degree of automation of production of an industrial enterprise;

$S_{min}^a$  – the degree of automation of the first quartile of competitors;

$S^i$  – the degree of informatization of business processes of an industrial enterprise;

$S_{min}^i$  – the degree of informatization of business processes of the first quartile of competitors;

$S^p$  – the degree of representation of the enterprise in the information space;

$S_{min}^p$  – the degree of presentation in the information space of the first quartile of competitors;

$S_{max}^E$  – competitiveness compared with industry leaders;

$S_{max}^a$  – the degree of automation of the last quartile of competitors;

$S_{max}^i$  – the degree of informatization of business processes of the last quartile of competitors;

$S_{max}^p$  – the degree of presentation in the information space of the last quartile of competitors;

$S_{avg}^E$  – competitiveness compared to industry average values;

$S_{avg}^a$  – the degree of automation of production in the industry average;

$S_{avg}^i$  – the degree of informatization of business processes in the industry average;

$S_{avg}^p$  – the degree of representation in the information space in the industry average.

The obtained comparative indices give an opportunity to estimate the competitive position of the industrial enterprise, depending on the ratio of distance to outsiders, leaders and average values. If  $S_{max}^E < S_{min}^E$  and  $S_{max}^E < S_{avg}^E$ , then we can conclude that the industrial enterprises are close to the leaders of the industry. If  $S_{min}^E < S_{max}^E$  and  $S_{min}^E < S_{avg}^E$ , then the company is an outsider. In the case when  $S_{avg}^E < S_{max}^E$  and  $S_{avg}^E < S_{min}^E$ , the company has a competitive, close to medium-sized industry.

The next component of the mechanism for assessing the competitiveness of an industrial enterprise in the information economy is a model for assessing the ability of an industrial enterprise to introduce new technologies that are constantly emerging in the information economy. The research on domestic and world successful machine-building enterprises makes it possible to conclude that the ability to implement new technologies depends on many factors, some of which may be considered key. Among them: a) availability of highly skilled personnel capable of adapting and implementing the latest technologies, b) sufficient qualification of the majority of personnel in the field of information technology use, c) availability of financial resources for implementation or the ability to attract them from the outside. Calculation of the absolute assessment of the ability of the industrial enterprise to introduce new technologies  $A^v$  are proposed to be carried out by drawing up all the received marks. The evaluation of these factors is suggested by analyzing relevant indicators (Table 4). Such a factor as the availability of highly skilled personnel capable of adapting and implementing the latest technology is considered to be the most important and can have a maximum value of 0.5, when all the units that can implement modern information technologies are present in the enterprise. The factor of sufficient qualification of the majority of personnel in the field of information technology may have a maximum of 0.25, at the same time only one of the listed options may be selected. Finally, the availability of financial resources also has a maximum value of 0.25, but consists of the sum of all the listed criteria.

In the case where the absolute assessment of the ability of an industrial enterprise to introduce new technologies is equal to one, this enterprise can be considered as fully adapted to the use of modern tools and technologies provided by the information economy.

The last element of the modeling mechanism for assessing the competitiveness of an industrial enterprise in the information economy is the integrated quantitative assessment of competitiveness. It is suggested, when calculating the integrated quantification, to use the indicators of the previous two models, namely: the degree of automation of production; the degree of informatization of business processes; the degree of representation of the enterprise in the information space; an absolute assessment of the ability to introduce new technologies. These four indicators are displayed in a four-dimensional space and form the corresponding figure.

Also in this space is a figure that consists of estimates of these indicators in the industry average. The integrated quantitative score in the result is the ratio of volumes of these two figures (Fig. 2).

Table 4: Assessment of the ability of the industrial enterprise to introduce new technologies

Factors of the ability to introduce new information technologies	Presence of a factor	Quantitative assessment
Highly skilled staff capable of adapting and implementing the latest technology	There is a research department	0.20
	There is a design bureau	0.20
	There is an IT department capable of self-development	0.10
Sufficient qualification of most personnel in the field of information technology use	More than 90% of the staff are confident users of computer technology	0.25
	From 50% to 90% of the staff are confident users of computer technology	0.15
	From 10% to 50% of the staff are confident users of computer technology	0.10
Availability of financial resources for implementation or the ability to attract them from the outside	There are sufficient amounts of undistributed profits of the enterprise	0.10
	There are own resources from the owners	0.10
	The enterprise has characteristics that provide it with cheap loans	0.05

Source: calculated by the authors.

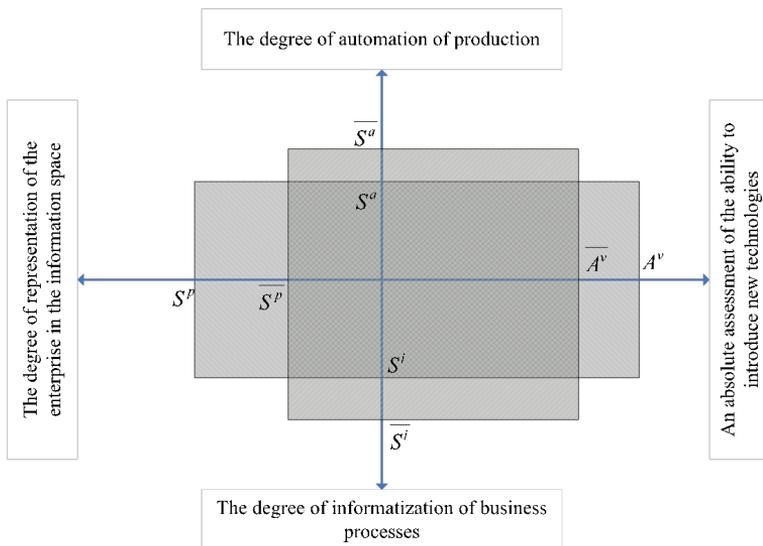


Figure 2. Representation of competitiveness of industrial enterprise and industry in projection

Source: own study

In addition to the model support, the mechanism for evaluating the competitiveness of an industrial enterprise in the information economy includes information support, which consists of an information system for monitoring the environment and an information system for analyzing the competitiveness of the enterprise. The first information system provides the collection and aggregation of data, which necessary for the assessment of competitiveness. The second provides the presentation of the results of the assessment of competitiveness in the form convenient for owners and managers, and also provides opportunities for analyzing the sensitivity of the components of competitiveness, their response to the change of indivi-

dual factors.

Thus, a mechanism for assessing the competitiveness of an industrial enterprise in the information economy has been developed, which implies a set of interacting elements and constitutes a holistic tool for collecting and processing information aimed at obtaining estimates of the competitiveness of an industrial enterprise in its operation in the conditions of the information economy. This mechanism provides the control system of the industrial enterprise on the basis of developing measures for its development in the conditions of the information economy, taking into account the existing and potential competitiveness of the enterprise.

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